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(54) Title of Invention: Resolver-type rotation angle detector

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## Specification

1. Title of Invention

Resolver-type rotation angle detector

2. Claims

In a resolver-type rotation angle detector device which detects the rotation angle using a resolver, a resolver-type rotation angle detector characterized in being provided with a two-phase excitation circuit which generates a two-phase alternating current with a mutual 90° phase difference for exciting said resolver, and a signal detection line which detects voltage induced in the resolver rotor, said two-phase excitation circuit, in addition to forming a circuit which outputs a two-phase alternating current comprising a pulse-width modulated waveform having a carrier frequency component sufficiently high compared to the fundamental wave, having interposed within it a low pass filter which at least removes from said signal detection line frequency components higher than said carrier frequency component.

3. Detailed Description

(Field of Industrial Use)

The invention relates to a resolver-type rotation angle detector device in which the angle of rotation is detected using a resolver.

(Prior Art)

Resolvers, as devices which simultaneously detect angle of rotation and angular speed, have in recent years offered the advantage of being both cheaper and more reliable than conventional rotary encoders (pulse pickups), especially with their increasing employment in servo motors.

The principle of said resolvers will be described briefly. A resolver consists essentially of a stator and a rotor, and when a two-phase alternating current with mutual 90° phase difference is made to flow in the two-phase windings of the stator, a phase-modulated voltage of $\sin(\theta + \theta r)$ is induced in the rotor windings.

Now, if the phase signal $\theta r$ is extracted from this voltage signal $\sin(\theta + \theta r)$, it is possible to detect the rotation angle $\theta$ of the rotor, and by differentiating this against time, to detect the rotation speed of the rotor $d\theta r / dt$.

Fig. 2 shows an example of the structure of the two-phase excitation circuit of a resolver. In this Fig. 2, 1 is a circuit which digitally outputs the two-phase signals sinθ and cosθ, with 2 and 3 being D/A converters which convert the digital signals to analog signals, 4 and 5 being amplifiers which amplify the output of D/A converters 2, 3, 6 being a two-phase excitation-type resolver, 7 the resolver rotor (including a rotating transistor), and 8 the rotation angle/rotation speed detection circuit.

As shown in this Fig. 2, a two-phase alternating current with a 90° phase difference is supplied to the two-phase windings of the stator in resolver 6 from D/A converters 2, 3 via amplifiers 4, 5, as a result of which a phase-modulated voltage sin (θ + θr) is induced in the windings of rotor 7 of the resolver, it being arranged that rotation angle/rotation speed detector circuit 8 can detect rotation angle θr and rotation speed dθr / dt from this voltage.

Fig. 3 shows an example of a two-phase excitation circuit comprising a switch circuit of transistors or the like, in this Fig. 3, 9 being a circuit which generates and outputs a transistor switching pattern, 10, 11 being switching circuits which respectively supply excitation alternating currents with a 90° phase difference to the two phase windings of the stator of resolver 6 upon receipt of a switching pattern corresponding to sinθ, cosθ from switching pattern generation circuit 9 comprising such elements as single-phase bridge-connected transistors. In Fig. 3, parts identical to Fig. 2 are keyed with the same numerals. A 120° rectangular wave pattern is commonly used for said switching pattern.

In the device shown in this Fig. 3, a two-phase alternating current with a phase difference of 90° is supplied to the two-phase windings of the stator in resolver 6 from switch circuits 10, 11, and by this means a phase-modulated voltage of sin (θ + θr) is induced in the windings of resolver rotor 7, it being arranged that rotation angle/rotation speed detector circuit 8 can detect rotation angle θr and rotation speed dθr / dt from this voltage.

(Difficulties to Be Resolved by the Invention)

However, an expensive D/A converter is necessary with the conventional resolver-type rotation angle detection device, for example the device shown in Fig. 2, and given the additional need for adjustments to achieve a two-phase output with a precise 90° phase difference due to the differences in the offset and gain of the OP amplifiers at the output end of each D/A converter, waveform distortion is generated in the output of the OP amplifier corresponding to the resolver rotation speed caused by variations in the primary reactance due to changes in position of the resolver rotor, breaking the circularity the rotational magnetic vector of the resolver stator, and

magnifying the margin of error for detecting the resolver rotor position.

Moreover, in the case of the device shown in Fig. 3 a harmonic component of $6n \pm 1$is present with the 120° rectangular waveform used under normal circumstances, so the circularity of the rotational magnetic vector of the stator deteriorates, increasing the margin of error for detecting the angle.

The invention is thus a device intended to resolve these difficulties, and has the purpose of providing a resolver-type rotation angle detection device from which a precise two-phase alternating current can be obtained using an inexpensive and simple means.

(Means of Resolving the Difficulties)

For this reason, with the resolver-type rotation angle detector device of the invention, the two-phase excitation circuit is characterized, in addition to forming a circuit which outputs a two-phase alternating current comprising a pulse-width modulated waveform having a sufficiently high carrier frequency component compared to the fundamental wave, in having a low pass filter interposed which at least removes from said signal detection line frequency components higher than said carrier frequency component.

(Action)

With said resolver-type rotation angle detection device of the invention, the two-phase alternating current comprising the pulse-width modulated waveform having a sufficiently high carrier frequency component compared to the fundamental waveform is supplied to the stator of the resolver, and by this means an induced voltage with the rotor rotation angle data is output to the induced voltage signal detection line of the resolver rotor, but as this voltage signal contains a carrier frequency component (harmonic components) this is removed by a low pass filter. As a result, the phase-modulated fundamental wave component passes through the filter and is detected.

(Embodiment of the Invention)

An embodiment of the invention shown in the diagram will now be explained in detail. Fig. 1 is a block diagram showing an embodiment of a resolver-type rotation angle detection device, and in this Fig. 1, 12 is an oscillator which outputs a high-speed clock signal of 24 MHz for example, 13 being a counter which counts the clock signal output from oscillator 12, 14 being

a decoder which has pre-recorded within it the switching pattern corresponding to the digital signal from counter 13 in the form of a two-phase pulse-width modulated (PWM) sine wave signal, 15, 16 being respectively switch circuits which operate at high-speeds in response to the PWM signals corresponding to sin θ, cos θ, these switch circuits 15, 16 comprising respectively single-phase bridge-connected transistors and diodes connected in reverse parallel to these transistors, and arranged so that they output a two-phase alternating current with a 90° phase difference comprising a PWM waveform having a carrier frequency component sufficiently higher (by a factor of 10) than the fundamental wave. In other words, oscillator 12, counter 13, decoder 14 and switch circuits 15, 16 comprise the two-phase excitation circuit which generates a two-phase alternating current having a mutual 90° phase difference for exciting resolver 6.

Furthermore, in Fig. 1, 17 is the induction voltage signal detection line which detects the voltage induced in resolver rotor 7, a low pass filter 18 which removes the carrier frequency component (harmonic components) caused by the PWM being interposed in this induction voltage signal detection line 17.

Moreover, 19 is a waveform rectification circuit which rectifies the sin (θ + θr) phase modulated fundamental wave component (sine wave) from low pass filter 18 to a rectangular waveform, 20 being the latch circuit which acts as a rotation angle detector detecting rotation angle data θr by latching the digital values output from counter 13 at every 360°edge of the output signal from waveform rectification circuit 19.

By means of the above structure, a high-speed clock signal of 24 MHz is output from oscillator 12, decoder 14 operating by means of the signal output from counter 13 that receives this, outputting a PWM signal. This PWM signal has its carrier frequency set at a high-speed of 10 kHz or more, which is sufficiently greater than the fundamental wave, and so a precise two-phase alternate current is obtained from switch circuits 15, 16. By this means there is no need for an expensive D/A converter, and in addition the need for offset and gain adjustment is eliminated, the internal impedance of the excitation circuit is low, and as is possible to ensure that distortion in the fundamental wave due to load variations is low, a very circular stator rotational magnetic field can be obtained.

However, due to this type of PWM excitation, harmonics are present in the carrier frequency component in the induced voltage signal detection line 17 of the resolver rotor. This harmonic component can however be removed simply by low pass filter 18. This is due to the fact that the frequency component is greater than the fundamental wave by a factor of ten, and can be easily removed. As a result, it is possible to obtain a secondary voltage return waveform with a

satisfactory sine shape and low distortion, and by this means the phase difference $\theta r$ with the induced voltage can be accurately and digitally assessed, so the precision of rotation angle detection is greatly improved.

(Effect of the Invention)

As has been described above, according to the resolver-type rotation angle detection device of the invention, as the two-phase excitation current of the resolver is a high-speed carrier pulse-width modulated waveform that is higher than the fundamental waveform by at least a factor of ten, the harmonic component of the spectrum in the vicinity of the carrier frequency can be removed by passing it through a low pass filter in the secondary induced voltage signal detection line, it thus being possible to supply a precise two-phase alternating current by an inexpensive and simple means, with the advantage that by this means accurate angular rotation can be detected.

4. Brief Description of the Drawings

Fig. 1 shows a block diagram of the resolver-type rotation angle detection device in an embodiment of the invention. Figs. 2 and 3 are both block diagrams showing a conventional resolver-type rotation detection device.

In the diagrams, 6 is a resolver, 7 the resolver rotor, 12 an oscillator, 13 a counter, 14 a decoder, 15, 16 switch circuits, 17 an induced voltage signal detection line, 18 a low pass filter, 19 a waveform rectification circuit, and 20 a latch circuit.

In the diagrams, the same numbers indicate identical or similar parts.

Fig. 1:

6 --- resolver
7 --- resolver rotor
12 --- oscillator
13 --- counter
14 --- decoder
15, 16 --- switch circuits
17 --- induced voltage signal detection line
18 --- low pass filter

19 --- waveform rectification circuit

20 --- latch circuit